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EVALUATION OF CONTROL MEASURES FOR BLACK STAIN ROOT DISEASE IN PINYON PINE IN SOUTHWESTERN COLORADO

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ABSTRACT

Ceratocystis (Verticicladiella) wageneri has been a damaging pathogen to pinyon in southwestern Colorado. The epidemiology of this root disease has been studied extensively but little is known about control. Three methods of control were evaluated: 1. Tree removal, 2. soil fumigation, and 3. placement of a mechanical barrier in the soil. All methods failed to prevent the spread of black stain root disease.

Black stain root disease caused by the fungus Ceratocystis wageneri Goheen and Cobb (= Verticicladiella wageneri Kend.) is a damaging pathogen to pinyon (Pinus edulis Engelm.) in southwestern Colorado (Wagener and Mielke, 1961; Landis and Helburg, 1976; James and Lister, 1978; Johnson, 1984; and Sharon, 1985). This disease has been observed in Mesa Verde National Park since the early 1940's (Mielke 1942-47). The observations and conclusions on the biology of the fungus made by Mielke in the 40's, on what was then called Leptographium root disease, are still relevant today.

While much effort has been devoted to studying the epidemiology of this disease, little effort has been directed toward the development of control strategies. There has been much speculation but little work on this subject.

This study was an attempt to control the spread of individual disease centers of black stain root disease in pinyon pine.

METHODS AND MATERIALS

Several methods of control were attempted to limit the lateral spread of disease centers: (1) Felling all dead and diseased trees within a root disease center plus the first healthy trees along the perimeter of the disease center; (2) soil fumigation with Vapam to create a barrier; and (3) insertion of a polyethylene barrier into a trench between healthy and diseased trees. Each treatment was replicated three times. Method 1 was installed at the McPhee Reservoir Project, Dolores Ranger District, San Juan National Forest; methods 2 and 3 at Mesa Verde National Park. Plots were established in 1982.

Site selection criteria and installation details are given in the appendix.

RESULTS AND DISCUSSION

All the methods tested failed to prevent the spread of C. wageneri (Tables 1,2,3). Sanitation by tree removal appeared promising until 1986 when all sites had one or more infected trees along the edge of sanitized clearings (Table 1).

Table 1. Evaluation of tree removal as a means of preventing the spread of black stain root disease within pinyon pine on the San Juan National Forest

	SITES			
	GRAVEL PIT 1	GRAVEL PIT 2	SAGE HEN	HOUSE CREEK [1]
Number of trees cut at establishment (1982).	14	19	12	12 [2]
Number of cut trees with black stain.	9	11	9	7 [2]
Number of trees sampled along edge of sanitation zone.	33	25	19	18
Number of sample trees positive for black stain in 1984.	0	0	2	0
Number of sample trees positive for black stain in 1986.	1	4	10	2 [3]

[1] This plot did not get cut; used as a check plot.
[2] Trees marked for cut but were not cut.
[3] Trees within the sanitation zone.

Fumigation killed trees closest to the trench. Based on the number of live and dead trees with black stain it appears the fumigant was unsuccessful in killing C. wageneri under the conditions of this study (Table 2). The heavy clay soil of Mesa Verde, high soil temperatures and low soil moisture may have resulted in the rapid decomposition of Vapam. However, the treated area was soaked with water immediately after fumigation. There were rock outcrops at two sites which probably affected dispersion of the gas.

Table 2. Evaluation of soil fumigation as a barrier to the spread of black stain disease from centers to healthy pinyon pine in Mesa Verde National Park

	NUMBER OF TREES		
	1982	1984	1985
SEWAGE POND			
Positive within the center	3	5 \1	5 \2
Positive beyond the barrier	0	6	6
# DEAD TREES THAT WERE			
Negative	--	0	0
Positive	--	8	9
RUINS RD.			
Positive within the center	4	6	6 \3
Positive beyond the barrier	0	4	5
# DEAD TREES THAT WERE			
Negative	--	10	10
Positive	--	10	10
FIRE TEMPLE			
Positive within the center	3	3	\4
Positive beyond the barrier	0	0	\4
# DEAD TREES THAT WERE			
Negative	--	10	\4
Positive	--	3	\4

\1 Includes three living trees.
\2 Includes two living trees.
\3 Includes one living tree.
\4 Plot was clearcut subsequent to 1984 examination.

The polyethylene-lined **trench treatment** could not be evaluated because errors were made during site establishment. At two trench sites (Table 3) trees classified as positive for black stain were beyond the barriers at the time of barrier establishment. At the Balcony House site these trees were assumed dead for several years and the fungus inactive. At the Chapin site the infected trees outside the barrier were discovered after the trench was established.

However, the number of trees subsequently determined positive for black stain after treatment on Ruins Road (Table 3) and Sewage Pond and Ruins Road (Table 2) raises a serious question about regarding symptomless trees as disease-free when disease centers are present in the area.

Table 3. Evaluation of trenching between black stain disease centers and healthy pinyon pine to prevent spread of the disease in Meda Verde National Park

	1982\1	1984	1985
RUINS RD.			
Positive within the center	2	8(6)	10(2)
Positive beyond the barrier	0	1(1)	7(6)
BALCONY HOUSE			
Positive within the center	8	10(2)	12(2)
Positive beyond the barrier	2\2	4(2)	5(1)
CHAPIN			
Positive within the center	15\3	20(5)	21(1)
Positive beyond the barrier	3	10(7)	17(7)

\1 Year polyethylene lined trenches established.
\2 These trees were considered dead for several years and the fungus was assumed inactive.
\3 Discovered after trench was established.
() Indicate change from previous sampling.

A study of this nature requires that we make assumptions regarding disease-free trees. We could not sample every symptomless tree to verify the absence of black stain disease, to do so would alter the conditions under which the disease-free tree was growing. The wound inflicted for verification of black stain excludes the tree from the sample population if the disease is absent. Only at the conclusion of a study could direct examination by sampling alleged disease-free trees be permitted. Sampling is recommended at that time because many apparently symptomless trees can have black stain disease.

Movement of the fungus across barriers by insect vectors was not considered in this study. Transmission by vectors has not been demonstrated in pinyon pine at Mesa Verde, however, other studies with other hosts have implicated insect vectors in disease transmission.

Additional examinations of trench and fumigation sites have been terminated. We will continue to monitor the sanitation plots on the San Juan National Forest. Control of black stain disease in pinyon pine at Mesa Verde remains elusive.

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APPENDIX

CRITERIA FOR SITE SELECTION

a. Disease centers small and discrete.
b. Must consist of at least 1, but no more than 5 trees recently killed by C. wageneri.
c. Must be devoid of significant bark beetle activity.
d. Must be at least 60 feet from nearest disease center.
e. Must have enough green healthy pinyon adjacent to control area to adequately detect disease if control fails.

TRENCHING

In this method a trench 18-24" deep was dug between the diseased and residual healthy stand. The trench was located as follows:

1. Locate the tree killed by black stain farthest from the plot center.

2. Compute the radius of influence as follows; take tree diameter (inches) at soil line, add 2, and change number to feet (example: Diameter of the tree at base equals 7.2", add 2 which is 9.2, therefore, your number is 9.2 feet).

3. Visualize a circle surrounding the diseased tree with a radius equal to the number calculated in step '2' above (example: 9.2 feet radius).

4. Calculate radius of influence for adjacent "healthy-appearing" pinyon (step 2).

5. If the two areas of influence for the diseased tree and a healthy tree overlap, examine root collar of "healthy-appearing" tree (see Figure 1).

6. If root collar of "healthy-appearing" tree is indeed healthy go to step No. 9.

7. If root collar of "healthy-appearing" tree is diseased, this tree now becomes last diseased tree and you repeat steps '1' through '7'.

8. Examine all diseased/"healthy-appearing" tree relationships where their areas of influence overlap.

9. Trench is to be constructed at outer limit of area of influence for last diseased tree encountered.

10. Outline trench location with stakes.

11. Get approval for the trench location from National Park archeologist before proceeding any further.

After the trench has been completed (18-24" deep by 6-12" wide) place a vertical polyethylene (4 mil) barrier along one wall of trench. Backfill until within 4" of original soil line. Place any polyethylene which is above this point inside of trench. Complete backfill. Stake location for future reference.

If, during the construction of the trench, black stain diseased roots are encountered, the trench must be moved outward from the diseased tree.

CHEMICAL BARRIER

The effect of a chemical barrier to the spread of root disease is similar to that of trenching. However, instead of a physical barrier in the form of polyethylene sheeting, the barrier is formed using the soil fumigant Vapam (sodium N-methyldithiocarbamate dihydrate). Vapam kills all living organisms in the treated soil including tree roots and the black stain pathogen. The barrier is a zone which is devoid of suitable substrates which the fungus can colonize.

The center-line of the area to be fumigated is located using the same procedure as in the trenching study. Treatment consists of applying chemical to a zone 3 feet wide. 350 ml of chemical is poured into holes dug 8-12" deep and spaced on an 18" grid centered on the perimeter of the zone of influence. After the chemical application, the hole is immediately covered with soil and the soil is moistened with water to prevent lose through volatilization.

TREE REMOVAL

Establish the center of the disease pocket. Examine the green tree closest to the center along each azimuth. Examine for black stain. If disease-free, mark the tree for removal and let the next green tree along each azimuth establish the edges for the sanitation area.

If the first green tree along an azimuth is infected, examine the next tree until a non-infected tree is found. Mark it for removal and use the next farthest green tree as the edge for the sanitation area.

Continue the process until the disease center to be sanitized is surrounded by a boundary of living and assumed non-infected trees.

Log and map stumps of all trees removed. Record presence or absence of black stain.